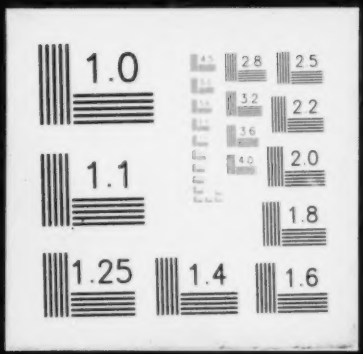
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| Nelson Forest Region | **Preliminary Height Expectations of Engelmann Spruce Plantations for Three Elevations in the Nelson Forest Region**<br>**by**<br>**Chris Thompson** | |
|---|---|---|
| | Research Summary 020 | |

## INTRODUCTION

Knowledge of expected height growth of newly established plantations is important in many aspects of forest planning. Achievement of free growing status and subsequent green-up considerations affect harvesting scheduling through adjacency rules and ultimately allowable cut calculations. The Timber Supply Review process has shown the latter to be particularly sensitive to variations in the number of years used for green-up achievement. Equivalent Clearcut Area calculations for hydrological recovery are also highly dependent on plantation height growth.

- ***Years to breast-height range from 8 to 11 years***
- ***Years to a height of 3 metres range from 14 to 19 years***

## METHODS

Between 1990 and 1993, three Regeneration Performance Assessment (RPA) surveys were conducted on 136 spruce plantations in the Nelson Forest Region. Criteria for plantation selection included (1) age between 4 and 16 years, (2) plantation size greater than 10 ha, (3) circum-mesic soil and nutrient characteristics. Potential plantations were preselected from ISIS, then ground checked for suitability. Lack of access often precluded use. Neither plantations where stand tending activities had occurred within the last two years nor those with serious observable damage were included.

The assessment was then conducted on each suitable plantation using 50 $m^2$ (r=3.99 m) temporary plots systematically spaced on a line located to sample the majority of the plantation. At least 50 trees per plantation were measured. The current height and the heights of preceding internodes were recorded. In this way, a growth segment of at least five years was obtained for each tree. These segments were averaged for each plantation (Figure 1). RPA procedures are fully documented by Pollack et al., 1985 (2).

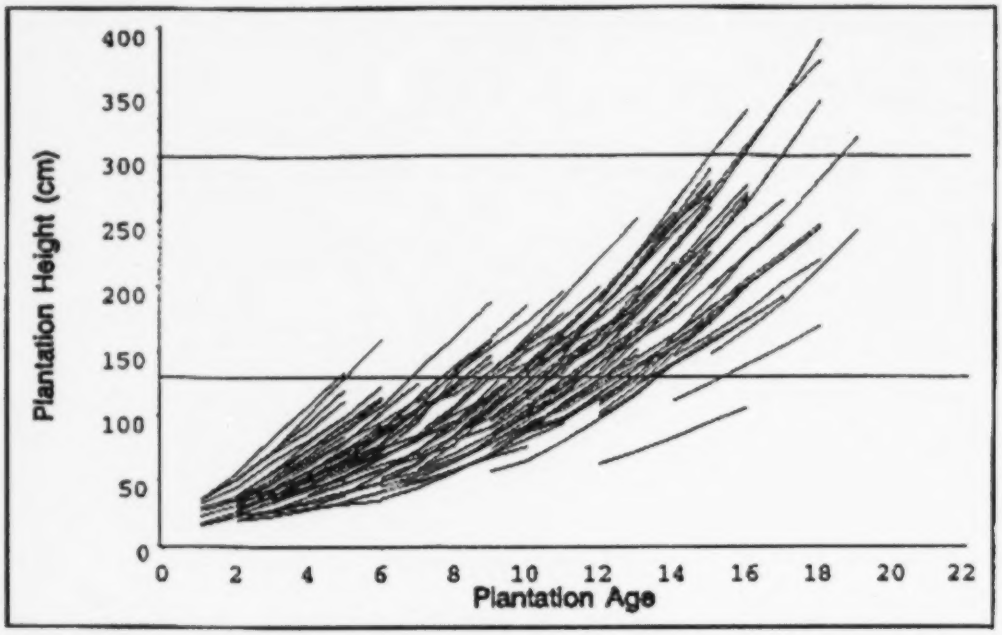


***Figure 1.*** *Growth segments from 136 spruce plantations in the Nelson Forest Region. Reference lines are shown at default green-up and breast-height.*

## RESULTS

Sampling was geographically incomplete. NTS grids 82E, 82J, 82L, 82M and 83D each included fewer than five sampled plantations and fewer than 10 sampled plantations were located below 700 m or above 1700 m. Sampled plantations included 68% on burnt sites, 16% on mechanically prepared sites and 16% on unprepared sites, with good geographical distribution across elevations and ages. Although we sought some correlation with site preparation methods, subsequent analysis showed that site preparation effects could not be reliably identified in this data set.

To eliminate dependency, only average plantation height at the time of sampling was used for model development. Under-sampling of higher elevation plantations and older, low elevation plantations produced an initial model that inadequately described the variations known to exist in spruce plantations. Three separate models for elevations of 800 m, 1200 m and 1600 m subsequently produced relationships that better described the variations experienced (Figure 2.) The models are of the form:

$$\text{height} = e^{(a + b(\text{age}) + c(\text{elev})2)}$$

Model coefficients are shown in Table 1. Predicted plantation mean heights for the three elevations are shown in Table 2.

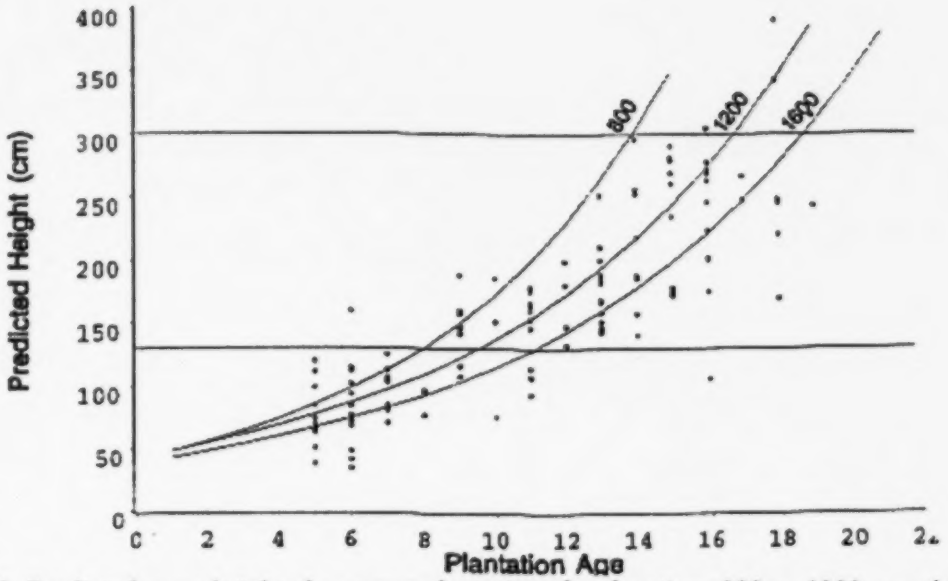


***Figure 2.*** *Predicted mean heights for spruce plantations for elevations 800 m, 1200 m and 1600 m derived from individual models for each elevation. Reference lines are shown at default green-up and breast-height.*

| Elevation (m) | a | b | c | adj $R^{2}$* | SEE (m)** |
|---|---|---|---|---|---|
| 800 | 4.0265 | 0.1409 | -0.00000045 | 0.703 | 0.211 |
| 1200 | 4.2010 | 0.1149 | -0.00000030 | 0.860 | 0.180 |
| 1600 | 4.1445 | 0.1090 | -0.00000019 | 0.702 | 0.283 |

* adj $R^{2}$ is the proportion of the total variation accounted for by the model
** SEE is the standard error of the estimate (p=0.05)

***Table 1.*** *Model coefficients for three elevations.*

| Plantation Age (yrs) | Elevation (m) | | |
|---|---|---|---|
| | 800 | 1200 | 1600 |
| 5 | 85 | 77 | (67) |
| 6 | 98 | 87 | 74 |
| 7 | 113 | 97 | 83 |
| 8 | 130 | 109 | 93 |
| 9 | 150 | 122 | 103 |

| | | | |
|---|---|---|---|
| 10 | 172 | 137 | 115 |
| 11 | 198 | 154 | 128 |
| 12 | (228)* | 173 | 143 |
| 13 | (263) | 194 | 160 |
| 14 | (303) | 217 | 178 |
| 15 | (348) | 244 | 198 |
| 16 | (401) | 273 | 221 |
| 17 | (462) | 306 | 247 |
| 18 | - | 344 | 275 |
| 19 | - | 386 | 307 |
| 20 | - | (433) | (342) |
| 21 | - | - | (382) |
| * Predicted heights shown in (brackets) are extrapolated beyond the range of the data | | | |

***Table 2.*** *Predicted mean heights (cm) for Engelmann spruce plantations in the ESSF and ICH zones of the Nelson Forest Region, based on analysis of 136 plantations established between 1968 and 1989.*

**DISCUSSION**

Using these models, the number of years needed to achieve breast-height at 800, 1200 and 1600 m are 8, 9.5 and 11 years respectively. When predicted values from these models are compared to the actual values on which the models are based, discrepancies become evident. For example, proportionally more plantations in NTS grid 82N have plantation mean heights lower than predicted values. The reason for this is unclear. Most of the sampled plantations in that grid are east of the Purcell and Selkirk Mountains. It is possible that the more severe climate of that area has a negative effect on growth. Plantations from the same latitude, but on the west of those mountains, mostly meet or exceed the respective predicted values. Other grids which are inadequately sampled may also exhibit lower than predicted mean heights.

Aspect and slope are currently not considered in the model. Observation suggests that incorporation of these factors into the models should improve the relationships developed. These data are not sufficiently well developed at this point for inclusion. Similarly, latitude (1), soil moisture and soil nutrients (3) have also been shown to impact significantly on site index calculations. Latitude is not available in the data set. All plantations were selected to be circum-mesic, thus providing insufficient range for incorporation of soil moisture or nutrient status into the models.

Attempts to extrapolate from both the 1600 m model and the initial model, to elevations above 1900 m produced predicted mean heights greater than experience suggested should be appropriate. There were no sampled plantations to be used for validation.

Height criteria for green-up achievement vary with resource unit objectives and base assumptions for each Timber Supply Area. Green-up heights can thus vary from the 3 m default, up to 20 m when visual

quality, wildlife habitat or watershed values are significant planning features. The models presented here provide a method of determining green-up time for resource units where 3 m is used as green-up height and spruce is the leading species. As attempted extrapolations to heights above 4 m proved unreliable, different strategies will be required to develop age estimates for planning units with taller green-up requirements.

In addition to harvest scheduling applications, these models can be used as standards to help answer other silvicultural questions, such as:

- Does the measured height of this plantation meet the standards?
- Why is the plantation performing below standard?
- How many other plantations are below standard, and what are the implications of this non-achievement?
- Is a silvicultural treatment available that will enable the plantation to achieve these standards?

The performance of a plantation is determined by many inter-related factors, many of which cannot be isolated using RPA approach. However, benchmark averages such as those presented here can assist in the diagnosis of problem plantations and in the development of techniques for program improvement while providing a standard for plantation performance assessment.

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